Breakpoint Analysis of MODIS Vegetation Cover Change in Southern California Deserts

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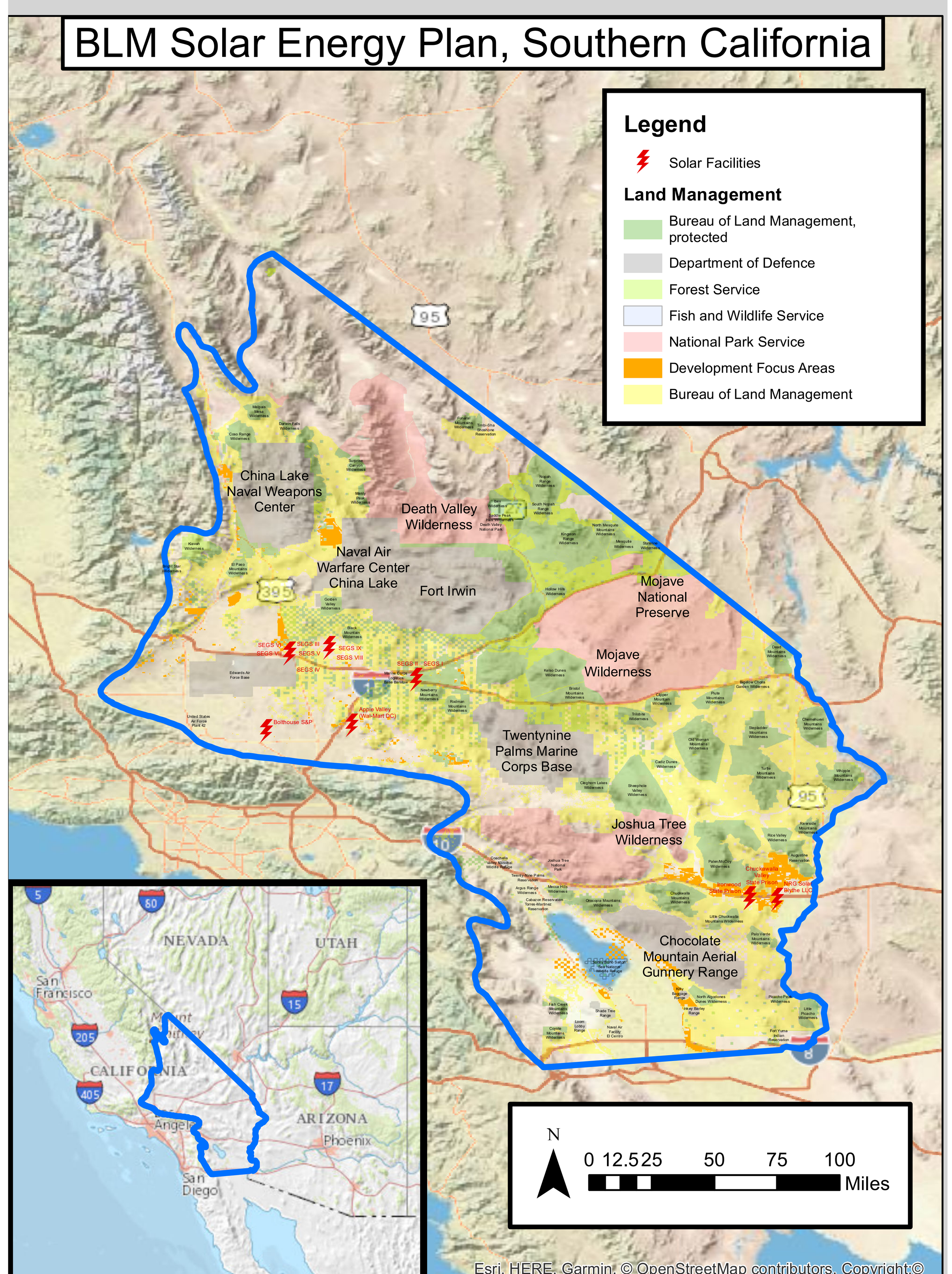
Introduction

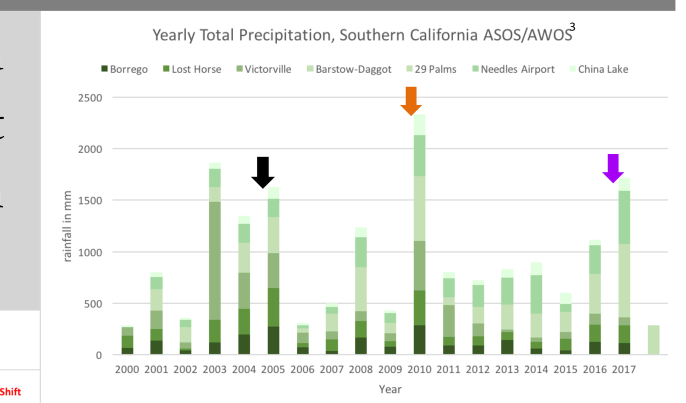
The Desert Renewable Energy Conservation Plan (DRECP) is a joint collaboration between California bureaucracies which aims to protect California natural ecosystems while allowing for systematic development of renewable energy. Together with environmental organizations, private energy companies, and other stakeholders they have created a land use plan that includes Development Focus Areas (DFAs): land that is logistically viable for renewable energy and has low or manageable environmental risk. Past studies have looked at the DRECP land using Landsat data in order to analyze any changes the environment has gone through due to renewable energy development or other factors. This study develops a method for utilizing structural change models to study the DRECP land area.

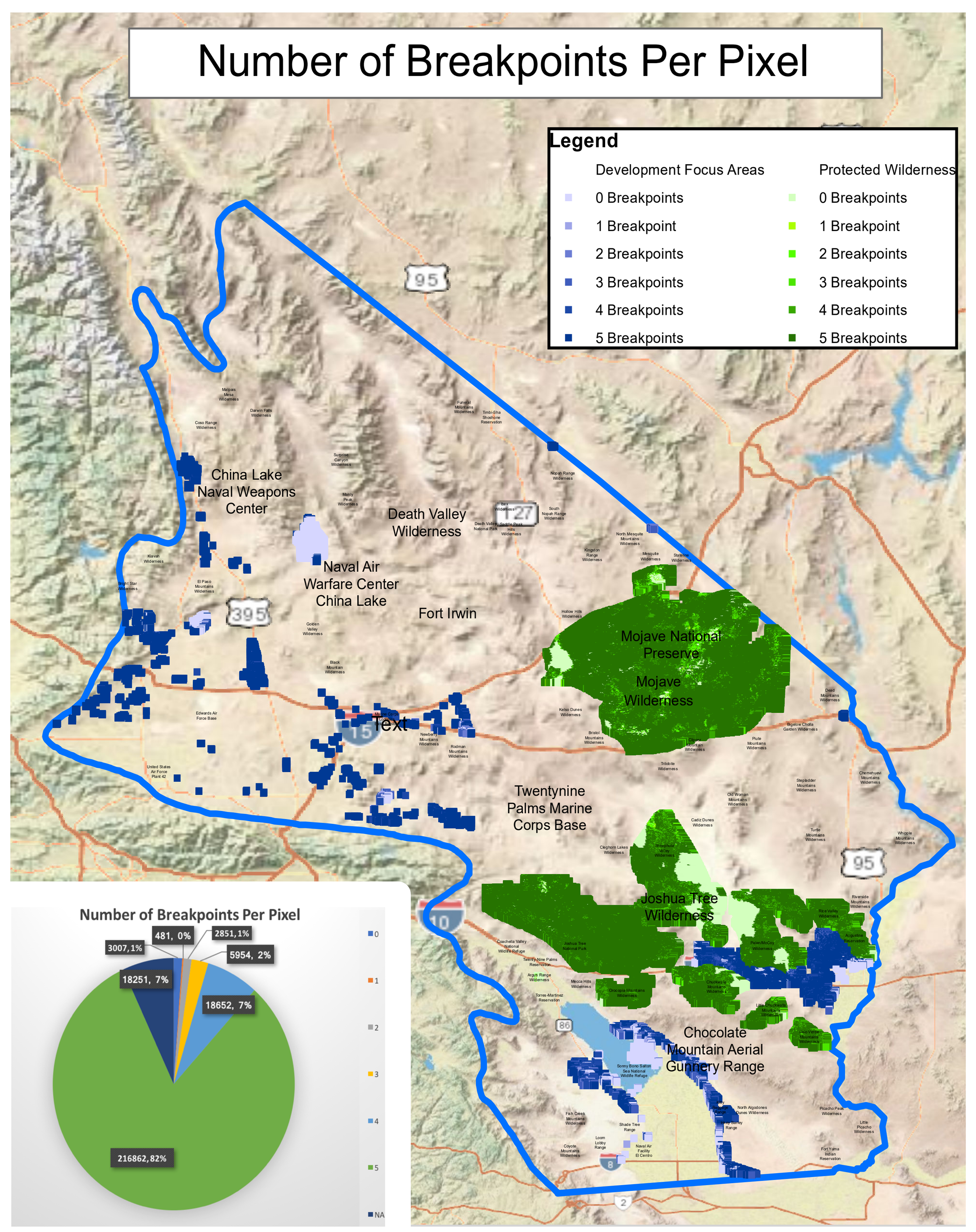


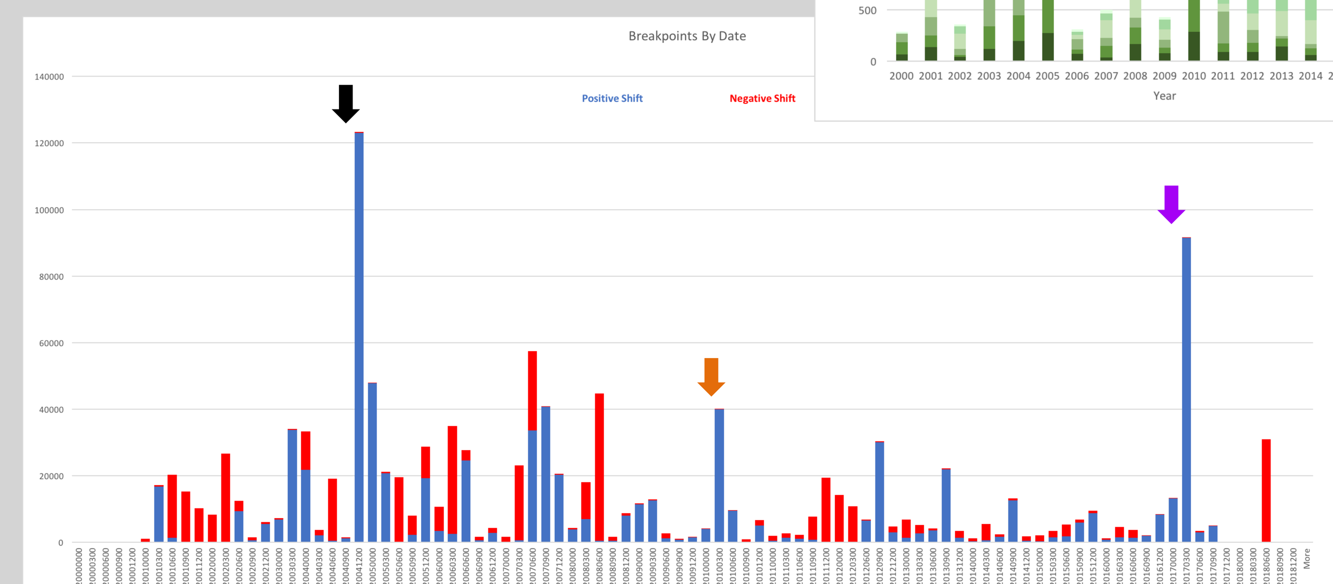
DRECP boundary with development focus areas and protected wilderness areas[1]

Results

The vast majority of pixels (82%) had the maximum number of breaks allowed by Breaks For Additive Season and Trend Project (BFAST)[2]. This indicates that our focus areas have multiple statistically significant structural changes from 2000 to 2018. These pixels are dark green or dark blue on the map to the left.

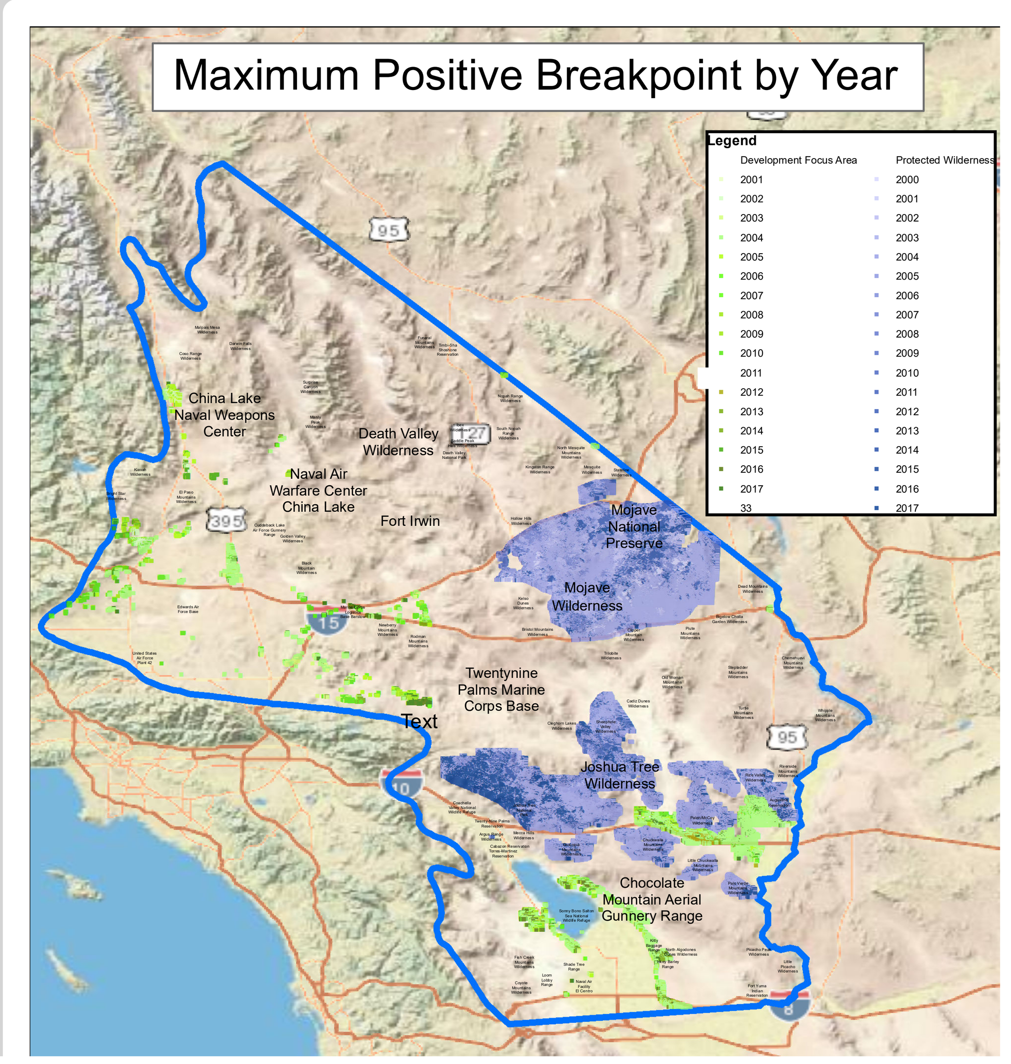






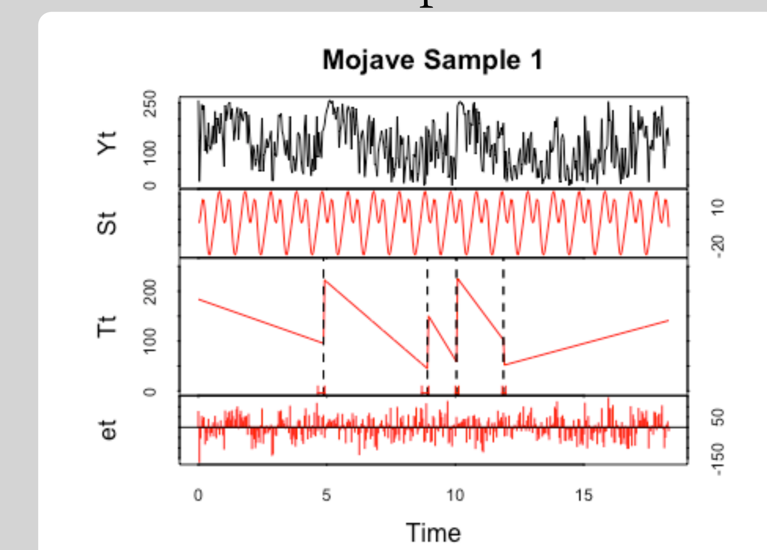
- Overall, positive breakpoints reflected above-average rainfall years, as indicated above by comparing the breakpoints by date and precipitation by date.
- December 2004 to February 2005 had the greatest concentration of positive breakpoints. 36% of pixels with breakpoints have a maximum positive shift in December of 2004. This cluster of breakpoints is below the black arrow.
- With the exception of Victorville weather station, 2004 or 2005 was an above rainfall year in the area, as shown by the Yearly Total Precipitation graph above.

- Pixels with zero breakpoints are clustered in sandy washes and active dunes with little to no vegetation. See the light-green and light-blue areas on the map above.
- When considering the maximum positive breakpoint for each pixel, the DFA's have a large concentration in 2003-2005 range. The protected wilderness has more variation, particularly in Mojave Wilderness and Joshua Tree Wilderness with maximum breakpoints in 2015-2018. These clusters correspond mountainous regions.
- Regardless of land being DFA or protected wilderness. Higher elevation areas are more likely to have more breakpoints.
- Timing of breakpoints correlate with years of higher than average rainfall regardless of land being DFA or protected wilderness.



Methods

Part of NASA's Earth Observing System, Terra is a satellite with a Moderate Resolution Imaging Spectroradiometer (MODIS) which collects from the .4 to 14.4 µm spectral band to get surface temperature, real images, and vegetation indices. The Normalized Difference Vegetation Index (NDVI) $NDVI = \frac{NIR - RED}{NIR + RED}$ measures density of green, where zero indicates no vegetation and .9 indicates thick vegetation. Previous research used an R package entitled BFAST. See BFAST output below.



Example of a BFAST output for one pixel in the Mojave Desert with four breakpoints

- Yt is the MODIS NDVI 16-day data
- St is the seasonal model fit to Yt based on a time series frequency input.
- Tt shows the trends with breakpoints. The trend component is a piece-wise linear function with breakpoints, or sudden jumps in values. Breakpoints are detected by minimizing the magnitude of the remainders over all the data.
- Et is the residual NDVI once the trend and trend values have been removed.

In order to analyze the entire Mojave Desert region, we created a package that ran BFAST with a breakpoint detection threshold of $p < .05$ over all pixels in a defined region. We input the maximum monthly NDVI from 2000 to 2018 at 250-m resolution and output a table including breakpoints and trend slopes.

Acknowledgements

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